

# Development and Practical Application of a Relationship Diagram-creation Tool Centering on Automatic Creation Functionality

Norio Ishii<sup>1</sup>, Yuri Suzuki<sup>2</sup> and Saori Sakuma<sup>3</sup>

<sup>1</sup>*Aichi Kiwami College of Nursing, 5-4-1 Jogan-dori, Ichinomiya, Aichi, Japan*

<sup>2</sup>*College of Engineering, Chubu University, 1200 Matsumoto-cho, Kasugai, Aichi, Japan*

<sup>3</sup>*School of Nursing, Seirei Christopher University, 3453 Mikatahara-cho, Kita-ku, Hamamatsu, Shizuoka, Japan*

**Keywords:** Nursing Education, Learning Support Tool, Relationship Diagram, Automatic Creation.

**Abstract:** In nursing education, learning the effects of relationship diagrams drawn by students is useful in understanding patients and the entire nursing process. However, drawing these diagrams is time consuming, and the diagram creation process is strenuous for students. In this study, we have developed a relationship-diagram creation tool that further reduces the difficulty of node organization. In particular, we have developed a tool that implements an automatic drawing function in which the tool, rather than the student, organizes information in the diagram. We conducted lectures on methods to use the tool at a nursing college as well as a questionnaire survey to evaluate its efficacy. On the basis of these results, we confirmed the improvements in the tool's usability and efficacy.

## 1 INTRODUCTION

The creation of relationship diagrams is important in the nursing process. Relationship diagrams are "concept maps" or "concept networks" that logically use arrows to depict the causes of illness, organic changes, functional changes, symptoms, and decreasing lifestyle activity to understand a patient. Relationship diagrams are used in basic nursing education to organize and integrate related information and present an overall image of a patient. They are important in determining the course the nursing process takes (Akinsanya and Williams, 2004; Hsu and Hsieh, 2005).

Earlier research has reported the use of relationship diagrams in nursing education to reinforce logical thinking and understanding (Sugisaki and Ogawa, 2006; Yakushijin et al., 2006). This study has noted that consolidating information improves learning and critical thinking abilities. However, it has been pointed out that the placement of nodes and lines in relationship diagrams make them difficult to draw and revise (Sugisaki and Ogawa, 2006). This suggests that, for students, the creation of relationship diagrams is a complex and difficult activity that requires an understanding of

the patient, an ability to follow the nursing process, and critical thinking capabilities.

As the earlier study suggested, creating relationship diagrams has merits, such as (1) promoting understanding of the patient as a whole and (2) improving logical and critical thinking capabilities. The current study focuses on (1) and aims to construct a learning environment for beginners to support the understanding of the patient as a whole.

Earlier studies tested a number of methods to increase the effectiveness of relationship diagrams as a learning tool, as described in (1), by avoiding confusing the students with detailed rules, including giving students rules for drawing diagrams that distinguish between actual and potential conditions and depicting different elements of information with different colors (All and Havens, 1997; Schuster, 2002; Toyoshima et al., 2005). These practical studies can be seen as a research approach that supports students by proposing effective rules for drawing relationship diagrams, which have not had clear and established drawing rules.

In contrast, the authors have performed research based on the development of a learning support tool for creating relationship diagrams and constructing a

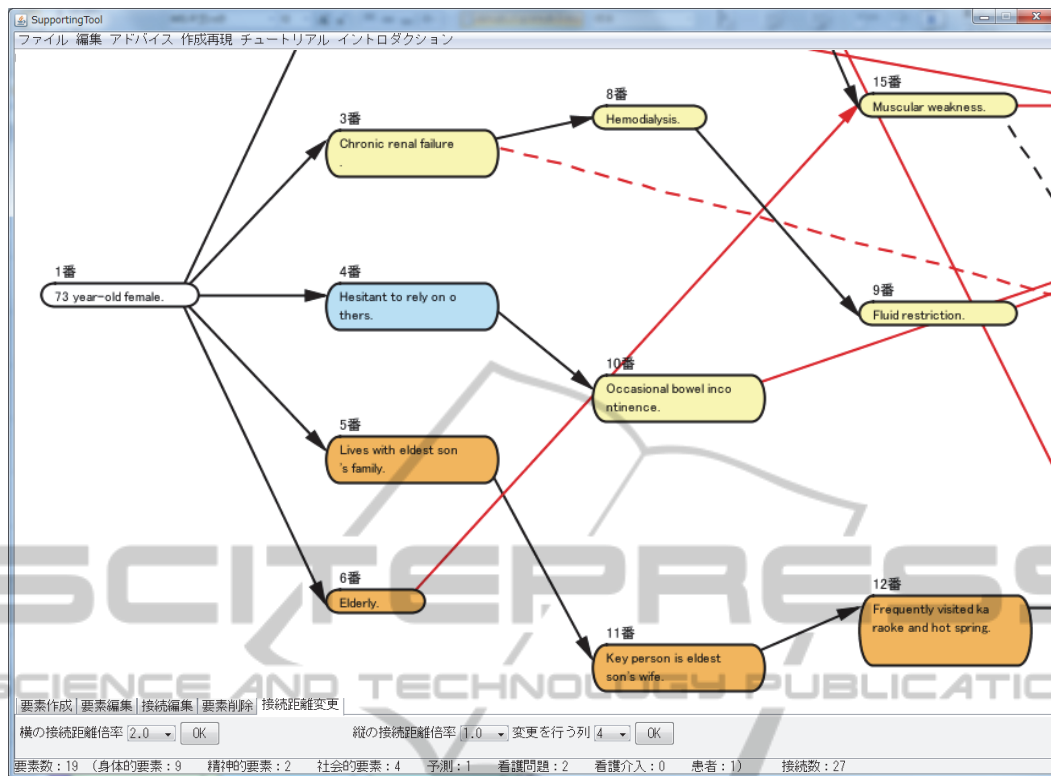


Figure 1: Relationship-diagram creation tool.

learning environment that reduces the previously mentioned student difficulties. In previous research, we developed a computer-based tool for simple creation of relationship diagrams using Microsoft Excel VBA and introduced this program into the classroom in an attempt to reduce the burden of diagram creation (Ishii and Sakuma, 2011). Using this tool allowed students to easily create and organize relationship diagram nodes and links. In practical use, the tool received positive evaluations from students in terms of creating and editing diagrams. However, no difference was seen in the amount of time required to create a diagram with the tool and the time to create a diagram by hand. We inferred that this was because the time spent by students on editing tool-generated diagrams was greater than that spent on hand-drawn diagrams since the tool allowed students to easily rearrange nodes.

In this study, we have developed a relationship diagram-creation tool that further reduces the burden of node organization. Specifically, we developed a tool that implements an automatic drawing function in which the tool rather than the student organizes information in a diagram. We then deployed this program in a classroom. In addition, we made improvements to the tool based on student

evaluations, and we investigated the effects of the improvements by introducing the program in the classroom once again during the following academic year.

## 2 A RELATIONSHIP DIAGRAM-CREATION TOOL

### 2.1 Development Environment

We developed the tool in the Java development language under the Windows operating system. During development, we used three libraries: Processing, which is specialized for graphics functions; Apache POI, which reads and writes files in formats for Microsoft applications such as Excel and Word; and JFreeChart, which allows creation graphs from Java applications.

### 2.2 Tool Functions

In this study, we developed a relationship diagram-creation tool with three functions: an automatic drawing function, a creation process replay function, and an evaluation support function (Figure 1).

### 2.2.1 Automatic Drawing Function

The tool automatically creates diagrams based on information entered by the student. We call this the automatic drawing function. The diagrams are composed of nodes and links, and nodes are hierarchically organized from left to right. Relationship diagrams are generally composed in a radial shape; however, based on interviews with nursing instructors, we have adopted a hierarchical composition, which was assessed as easy to read.

To create a node, the user selects the “create element” tab from the lower part of the tool. After inputting the target information for the new element, the user selects element properties and connecting element numbers (a node number pointing to a higher level in the hierarchy) from the menu. This automatically creates a new node in a color based on its properties and places the node in the diagram. The node is also automatically assigned a number in order of creation. There are six element properties: (1) physical attributes (height, weight, ailments, etc.), (2) social background elements (family composition, household environment, etc.), (3) psychological state elements (mental state, mental issues, etc.), (4) expectations (future expectations regarding the patient), (5) nursing obstacles (critical issues concerning nursing), and (6) nursing intervention (nursing activity for the subject patient).

To edit node information, the user selects the “edit element” tab, and then selects the number of the node they wish to edit from the pull-down menu. Current information is shown in the content field of the element. Current information can be edited. When the OK button is pressed, these changes are reflected in the diagram. Nodes can be deleted by selecting the “delete node” tab and selecting the number of the node to be deleted from the pull-down menu. However, to preserve links, only nodes with no lower level nodes can be deleted.

Links between nodes are automatically generated, and normal links are indicated by solid arrows. Prediction links are indicated by dotted arrows. To add a link between nodes, the user chooses the “edit connections” tab and enters edit mode to select the number of nodes to be connected from the pull-down menu. The added link is shown with a red arrow. To delete a node, after selecting deletion mode, the user must then choose the number of the node to be deleted in a similar fashion.

Finally, as nodes and links are created automatically, the student cannot change their placement; however, by selecting the “change

connection distance” tab, the users can adjust the spacing between nodes.

### 2.2.2 Creation Process Replay Function

The tool automatically logs the creation process of the relationship diagram and can recreate this process step by step after creation. This is called the creation process replay function. The creation process replay includes the deletion as well as addition of elements and connections. This function allows students and instructors to confirm a student’s creation process.

### 2.2.3 Evaluation Support Function

After the creation of a relationship diagram, this tool can display an evaluation sheet that shows the number of links and nodes of each type in a table as well as the proportion of nodes of each type as a graph. This is called the evaluation support function. Evaluation sheets are output in a Microsoft Excel-compatible format.

## 3 INTRODUCING THE TOOL IN THE CLASSROOM

### 3.1 Course and Object of Study

In this study, we introduced the developed relationship diagram-creation tool into a classroom. The target course was “The Nursing Process,” a first year open lecture at a short-term nursing school. One of the course’s fifteen total classes focuses on the creation of relationship diagrams. There were 88 first-year short-term nursing college (school of nursing) students in the class.

### 3.2 Class Design

The class content was composed of three steps: introduction of the tool, creation of relationship diagrams, and evaluation and improvement of diagrams.

In the first step, students received a basic explanation of the fundamentals of the tool. Specifically, students received an explanation regarding the creation, revision, and deletion of nodes as well as the addition of nodes and adjustment of spacing between nodes. The procedure for saving files was also explained.

In the second step, students were divided into groups of two to three and created one full image

Table 1: Evaluation items.

No.	Usability	Efficiency
1	I think that I would like to use this tool frequently.	It didn't take long.
2	I found the tool unnecessarily complex.	It was possible to draw diagrams easily.
3	I thought the tool was easy to use.	It was possible to draw diagrams neatly.
4	I think that I would need the support of a technical person to be able to use this tool.	It was possible to draw diagrams in detail.
5	I found the various functions in this tool were well integrated.	It was easy to erase nodes or links.
6	I thought there was too much inconsistency in this tool.	It was easy to revise diagrams.
7	I would imagine that most people would learn to use this tool very quickly.	It was easy to rearrange nodes or links.
8	I found the tool very cumbersome to use.	It was useful to classify information by kinds of color or line.
9	I felt very confident using the tool.	It was easy to organize information.
10	I needed to learn a lot of things before I could get going with this tool.	It was easy to consider relationship.

relationship diagram based on a given case (symptoms associated with stroke, physical changes associated with aging, and the effects of these symptoms on daily life). Because the students are beginners at creating diagrams, we distributed a data file in which one portion related to the illness was created in advance. Students completed a relationship diagram by adding information to the distributed diagram.

In the third step, students used the evaluation sheet provided by the tool to assess the created relationship diagram. Students then added supplementary information and revised incorrect information. Finally, students reviewed the creation process using the creation process replay function. After the diagram creation process finished, students assessed the tool following the same process used in earlier research (Ishii and Sakuma, 2011). More specifically, a system usability scale (Brooke, 1996) (10 items, 5-rank evaluation) was used to assess usability. Evaluation items based on points that the students considered difficult in earlier research were also used (10 items, 4-rank evaluation) to assess efficiency. The evaluation items are shown in Table 1.

### 3.3 Student Evaluation of the Tool

In our evaluation of the tool, we first compared evaluations received from students in this study with those obtained in earlier research (Ishii and Sakuma, 2011) regarding the previous relationship diagram tool. As explained in Section 1, the tool in this research varied from the previously developed tool as follows: (1) nodes were automatically created by entering information but students manually

organized the diagram; (2) similar to nodes, links were also manually organized by the students; and (3) the creation process replay functionality and evaluation support functionality were not implemented. In addition, creation of the relationship diagram was performed over two classes in previous studies, whereas in this study, the relationship diagram was created in a single class period.

#### 3.3.1 Usability Evaluation

Figure 2 shows usability evaluations for the previous and proposed tools. The system usability scale utilized in this study included inverted evaluation items. In Figure 2, positive evaluations are represented with higher values.

Figure 2 shows that the evaluations were higher for the proposed tool than the previous tool for all 10 evaluation items. A non-corresponding t-test performed for the average difference in total usability points between the previous and proposed tools confirmed that the proposed tool obtained a significantly higher average point total (33.9) than the previous tool's average (31.1) ( $t(146)=3.572$ ,  $p<.01$ ). However, the average point values were less than 3.0 for items 4, 9, and 10 in the evaluations of the proposed tool.

#### 3.3.2 Efficiency Evaluation

Figure 3 shows efficiency evaluation results for the proposed and previous tools. A non-corresponding t-test performed for the average difference for items 1 to 10 confirmed that the proposed tool obtained a significantly lower average than the previous tool's

average for item 7 ( $t(146)=2.377, p<.05$ ). While the proposed tool received higher point totals in most evaluation categories, we did not find a significant difference.

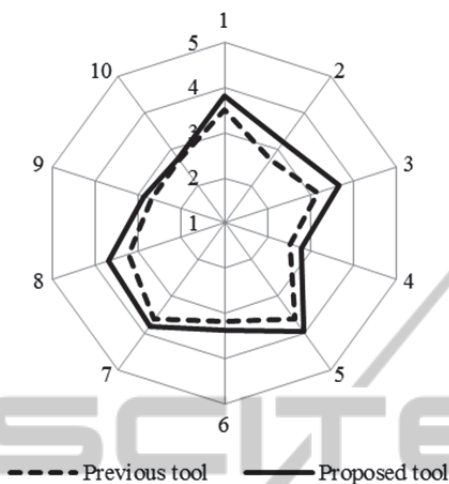


Figure 2: Result of usability evaluations using the previous and proposed tools.

### 3.4 Evaluations of Student Created Relationship Diagrams

To show the effect of the proposed tool on learning, we evaluated the relationship diagrams created by students and conducted student evaluations of the tool. This study established evaluation items for (1) the number of nodes for each type and (2) the number of links (excluding the crossing links mentioned below), which express the amount of information in the diagram, and (3) the number of crossing links (links that cross node levels; we observed activity when links were added to previously created nodes), which are used as an evaluation item in representative earlier research (Novak and Gowin, 1984). The subjects of analysis were relationship diagrams (14 from the previous tool, 30 from the proposed tool) created by consenting student groups.

Table 2 shows the results of analyzing the relationship diagrams created in experiments using the previous and proposed tools. Each item is represented by a number; however, this excludes data included in data files provided at the beginning of diagram creation. A non-corresponding t-test performed for the average difference for each evaluation item confirmed that diagrams created by the proposed tool had significantly more expectation nodes ( $t(42)=2.330, p<.05$ ) and crossing links.

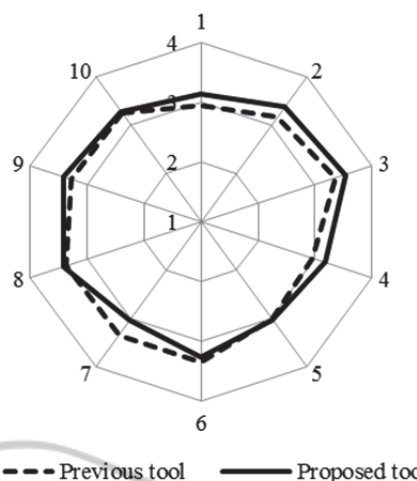


Figure 3: Result of efficiency evaluations using the previous and proposed tools.

Table 2: Results of analyzing the relationship diagrams using the previous and proposed tools.

Evaluation items	Previous tool	Proposed tool
Physical attributes	4.7	5.2
Social background elements	1.6	0.3
Psychological state elements	2.9	3.7
Expectations	1.1	2.2
Nursing obstacles	1.7	1.3
Nursing intervention	2.8	3.0
Links	15.7	14.8
Crossing links	2.9	6.8

( $t(42)=3.865, p<.01$ ) compared with those created by the previous tool. We also found that the relationship diagrams created with the previous tool had a significantly larger number of nodes regarding social background elements ( $t(42)=4.505, p<.01$ ).

### 3.5 Discussion

Usability evaluations of the tool confirmed that the proposed tool received higher overall evaluations than the previously developed tool. This suggests that the control methods and interface developed in this study were easy for the students to understand.

No significant difference between the previous and proposed tool was seen in evaluation of tool efficiency. Low evaluation of the proposed tool's ability to change the organization was due to the specifications of the proposed tool; students could not reorganize the diagram. As no difference was seen in other items, we hypothesize that this specification did not have a large overall effect on relationship diagram creation.



Analysis of the relationship diagrams created by students confirmed that the number of prediction nodes and crossing links increased with the proposed tool. This suggests that students actively investigated the possibility of future occurrences based on the provided information as well as the relationships among the information. Diagram creation required two class periods with the previous tool, whereas the proposed tool used only one. This indicates the efficiency of the proposed tool.

Future improvements could include strengthening support functions for promoting link creation and diagram nodes. In particular, the results showed that few social background elements were created by the proposed tool. In future, we aim to add additional functions to promote entry of such elements.

## **4 IMPROVING THE RELATIONSHIP DIAGRAM-CREATION TOOL**

### **4.1 Adding Functions to the Tool**

To increase the efficiency of the relationship diagram-creation tool introduced to the classroom in Section 3, we have implemented the following additional functions: an initial information entry function and a nursing problem extraction function.

#### **4.1.1 Initial Information Entry Function**

The initial information entry function supports activity at the beginning of the relationship diagram creation process. Students enter basic information regarding the patient using a template displayed in list format (age, sex, family composition, occupation, medical history, and disease name). This data is saved as an initial information file. By importing the initial information file through the tool menu, a relationship diagram based on all the information is displayed.

This function is expected to promote the creation of social background elements and physical attributes related to the target patient. We also expect this function to increase productivity of student data entry during the initial creation of the relationship diagram, reducing both data omissions and time required to create a diagram.

#### **4.1.2 Nursing Problem Extraction Function**

The nursing problem extraction function supports

evaluations after creation of the relationship diagram. As stated in Section 2.2.3, we implemented an evaluation support function that provided quantitative information related to the relationship diagram. However, evaluating the content of the created relationship diagram was difficult with this function. Thus, we implemented the nursing issue extraction function to assess the content of the relationship map effectively. By selecting this function, links are extracted from the initial information nodes to the nursing issue (crucial issues in nursing) nodes and displayed in another window (for example, “76-year-old woman > stroke > incontinence > damp skin > bedsores).

This function is expected to make it easy for students to conduct an evaluation by reviewing their thought process through a large quantity of information, which can promote understanding of the subject.

### **4.2 Introducing the Improved Tool into the Classroom**

We introduced the improved tool in a class to assess the effects of the improvements. As with the experiment described in Section 3.1, we used one class period of “The Nursing Process,” a first-year open lecture at a short-term nursing university. There were 82 first-year short-term nursing college (school of nursing) students in the class.

The class design was approximately the same as the previous class, with the following changes. (1) We added an explanation of the initial information entry function at the first step. (2) In the second step, students created a relationship diagram using the initial information entry function (students were given a printed sheet of information rather than a data file). (3) In the third step, the relationship diagrams were assessed using the nursing issue extraction function in addition to the evaluation sheet and creation process replay function. After the class, tool evaluation was performed using the same questionnaire. 66 students were targets of this analysis.

### **4.3 Student Evaluations of the Improved Tool**

In Section 3, we assessed the tool through comparison with the previously developed tool. Here we compare student evaluations of the proposed tool before and after implementing the improvements described in Sections 4.1.1 and 4.1.2.

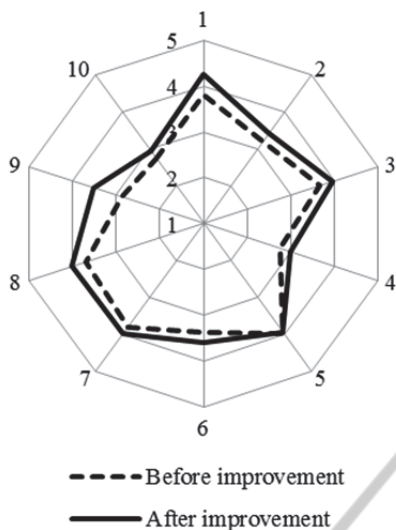


Figure 4: Result of usability evaluations of the tool before and after improvement.

#### 4.4 Student Evaluations of the Improved Tool

In Section 3, we assessed the tool through comparison with the previously developed tool. Here we compare student evaluations of the proposed tool before and after implementing the improvements described in Sections 4.1.1 and 4.1.2.

##### 4.4.1 Usability Evaluation

Figure 4 shows the usability evaluations of the tool as points before and after improvement. Figure 4 shows that the evaluations of the tool after improvement were higher in every item except 5. A non-corresponding t-test performed for the average difference in total points of usability for the tool before (33.9) and after improvement (36.6) showed that the improved tool received significantly higher average point totals ( $t(135)=2.855, p<.01$ ). Items 4, 9, and 10, which received evaluations with average point scores below 3.0 prior to improvement, rose above 3.0 after the improvements were implemented.

##### 4.4.2 Efficiency Evaluation

Figure 5 shows efficiency evaluation results of the tool before and after improvement. A non-corresponding t-test performed for the average difference in points for each evaluation item confirmed that the improved tool received significantly higher evaluations in items 1 ( $t(144)=2.365, p<.05$ ), 2 ( $t(144)=3.706, p<.01$ ),

and 10 ( $t(133)=2.882, p<.01$ ). No evaluations were significantly lower after improving the tool.

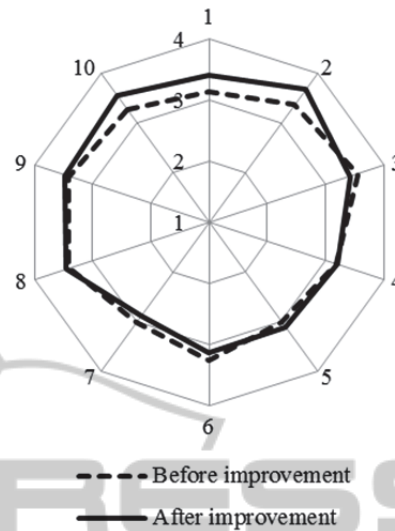


Figure 5: Result of efficiency evaluations of the tool before and after improvement.

#### 4.5 Evaluation of the Relationship Diagrams Created by Students

As with the relationship diagrams created with the proposed and previous tools, we assessed the diagrams created before and after improvement of the proposed tool. The subjects of analysis were relationship diagrams (30 with the unimproved tool, 20 with the improved tool) created by consenting student groups.

Table 3 shows the results of analyzing the relationship diagrams created using the tool before and after improvement. As in Table 2, the numerical values exclude information included in the data file. A non-corresponding t-test performed for the average difference in points for each item confirmed that diagrams created with the improved tool contained significantly higher nodes containing physical attributes ( $t(48)=3.751, p<.01$ ) and social background elements ( $t(48)=2.317, p<.05$ ). In contrast, we found that psychological state elements were significantly more numerous in the relationship diagrams created with the tool prior to improvement ( $t(48)=2.911, p<.01$ ).

#### 4.6 Discussion

Usability evaluations confirmed that the improved tool received higher overall evaluations than the tool prior to improvement. This suggests that the additional functions improved usability even further

when creating new relationship diagrams and assessing the created diagrams.

Table 3: Results of analyzing the relationship diagrams using the tool before and after improvement.

Evaluation items	Before improvement	After improvement
Physical attributes	5.2	8.8
Social background elements	0.3	0.9
Psychological state elements	3.7	2.3
Expectations	2.2	1.7
Nursing obstacles	1.3	0.7
Nursing intervention	3.0	3.5
Links	14.8	15.7
Crossing links	6.8	7.6

In addition, efficiency evaluations of the tool showed improvement in three evaluation items; in particular, 1, which considered creating diagrams, improved. The reason for this is thought to be that by adding the initial information entry function, it was possible to reduce the time required for students to enter information. In addition, 10, which considered the ease of thinking about relationships, also improved. This suggests that the nursing issue extraction function was effective in making relationships easier to grasp.

Analysis of the relationship diagrams created by the students confirmed that physical attributes and social background elements increased in the improved tool. This is thought to be because the improved tool reflects the results of continuing creation while the student focuses on social background elements, such as occupation and family composition, and physical attributes, such as medical history, through the initial information entry function implemented in the tool. We hypothesize that the reduction in psychological state elements was due to the absence of psychological state elements in the initial information.

In this study, during creation of the initial information we selected the basic information that we wanted students to enter in the relationship diagram. If the selected information had a strong effect on the content of the relationship diagram, we considered that it should include information that would serve to develop opportunities for further consideration; for example, problems during hospitalization and psychological state elements, such as what the patient does not want to do. In future, we aim to investigate this point through practical experiments.

## 5 CONCLUSIONS

The relationship diagram-creation tool developed in this study received more positive evaluation than tools developed in earlier research. We have also examined the effects of further improving the tool.

While this study conducted an analysis of the relationship diagrams created by the students, future research is aimed at performing detailed analysis of the creation process and experimentally investigating the effect of each function implemented to facilitate addition of knowledge obtained in the current study. Based on the results of this analysis, we hope to improve the tool further and create a more effective learning environment.

## REFERENCES

- Akinsanya, C., Williams, M., 2004. Concept mapping for meaningful learning. *Nurse Education Today*, 13(1), 41-46.
- All, A., Havens, R., 1997. Cognitive/Concept mapping: A teaching strategy in nursing. *Journal of Advanced Nursing*, 25(6), 1210-1219.
- Brooke, J., 1996. SUS: A "quick and dirty" usability scale. In Jordan, P. W. et al., (eds.), *Usability Evaluation in Industry*. Taylor and Francis.
- Hsu, L., Hsieh, S., 2005. Concept maps as assessment tool in a nursing course. *Journal of Professional Nursing*, 21(3), 141-149.
- Ishii, N., Sakuma, S., 2011. Supporting the creation of sequence of events in nursing education. *International Journal of Education and Information Technologies*, 5(2), 199-206.
- Novak, J. D., Gowin, D. B., 1984. *Learning How to Learn*. Cambridge University Press.
- Schuster, P. M., 2002. *Concept Mapping: A Critical Thinking Approach to Care Planning*. F.A. Davis.
- Sugisaki, H., Ogawa, I., 2006. Learning effects of use of sequence of events in adult nursing practicum (Acute period). *Bulletin of Nara Medical University School of Nursing*, 2, 1-6.
- Toyoshima, Y., Itou, F., Hagi, Y., Nishibori, Y., Kazaoka, T., Kishita, S., Itou, S., 2005. Evaluation of student learning about the nursing process using written simulation in adult nursing course (Part 3): Analysis of student self-evaluation in learning with sequence of events. *Bulletin of Department of Nursing Seirei Christopher College*, 13, 81-90.
- Yakushijin, Y., Murakami, E., Nakamura, K., 2006. Learning effectiveness of using concept maps in pediatric clinical nursing practice. *Journal of Japanese Society of Child Health Nursing*, 15(2), 8-14.